LCC ENGINEERING & SURVEYING, INC.

TECHNICAL MEMORANDUM

Date: November 4, 2016

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LCC Engineering & Surveying, Inc.

Subject: Pacheco Boulevard Improvements
Blum Road to Morello Avenue

SURVEY REPORT

This memorandum presents a summary of the surveying and mapping performed for the subject Study and Analysis. Services included:

- Control surveys
- Document research
- Aerial photography and topographic mapping
- Existing utility mapping

1. Control Surveys

Initial Surveys: To establish ground control for this aerial base mapping, LCC performed several localized RTK GPS surveys between 6/15 and 6/25/2015. Details of the surveys are more particularly described below.

Aerial control points were set on the ground during the GPS surveys. Flight panels in non-roadway areas consisted of "blue max" tarp panels secured to the ground with five hubs (at each corner and at center) or more as needed, with a nail in the center. Flight panels in paved or roadway areas (including shoulders) consisted of 3'x3' white painted "crosses". Painted flight panels in pavement areas were set with a 1-½" magnetic pavement nail (no washer) in the center of the painted flight panel. See attached data spreadsheet for point numbers, coordinates, elevations, and description of the control points set.

The coordinates of these control points were established using a RTK GPS Survey using Topcon HiPER PG1A Receiver units, cell phone communications, and using Topcon SurveyLink Mapping Plane Software to measure and convert geodetic coordinates while holding County GPS control point DE8504 for both horizontal and vertical position (per the coordinates listed on the NGS Data Sheet published on the NGS website, listed as based on NAD83 CCS Zone 3, Epoch 2010.00 and NAVD88). LCC also tied our survey

into (took check shots on) County GPS control point AA3808 (Epoch 2010.00), but did not hold for coordinates or elevation on this point.

The tribrachs and tripods were calibrated for leveling purposes prior to beginning the field work. A fixed rod with bipod leveling supports was used for the "rover" observations in order to minimize centering or "plumbing" errors often associated with RTK surveys. County control points and aerial mapping control points were observed for a minimum total of 90 seconds (each for a minimum of 3 – 30 second intervals). The GPS observations were repeated over multiple days, and each point was surveyed a minimum of three (3) times over the survey period.

An average coordinate and elevation was then calculated and residuals for data comparison are shown. See the attached data spreadsheets for the raw data, analysis and results of our survey. Based on our results, we believe that the resulting averaged coordinates have an approximated statistical 95% confidence in relative accuracy of ±0.02 feet horizontally, and ±0.03 feet vertically.

Published coordinates for aerial control points, monuments, benchmarks, and other control points accompanying this report should be considered grid coordinates and distances. To convert to ground distances, multiply grid distances by a combined scale factor of 1.00005931467 to obtain ground distances (combined scale factor calculated at precise alignment monument near Arthur Road).

Additional Surveys: In addition to establishing ground control for aerial mapping and subsequent supplemental mapping (by others), LCC performed additional RTK GPS surveys of existing horizontal control monuments and elevation benchmarks along the length of the project. LCC performed additional base station localized RTK GPS surveys, using the NGS Control Points described above. Surveys were performed between 8/07 and 8/08/2015. Details of these additional surveys are more particularly described below.

LCC researched all monuments along the Pacheco Boulevard corridor between Highway and just north of Morello Avenue using the County Precise Alignment maps and Record Subdivision, Parcel and Survey Maps. Of the 30 monuments shown on these record maps, LCC was able to recover and survey 12 monuments, spread relatively evenly spaced along the corridor. In addition, we found one record monument location possibly buried under the AC (not able to confirm), and one monument can which was filled with dirt which had no disk (not a record monument).

For the 12 monuments found, two of the monuments were excluded included in our survey but not held or included in our statistical analysis because only one set of data was obtained as the monuments were under adjustment and construction during our survey. The remaining ten (10) monuments were observed for a minimum total of 90 seconds (each for a minimum of 3 – 30 second intervals). Each point was surveyed a minimum of three (3) times over the survey period. The resulting averaged coordinates

have the following approximated statistical 95% confidence in accuracy: - ±0.02 feet horizontally, and ±0.03 feet vertically.

In addition, the County provided LCC with a list of nine (9) vertical benchmark points along the Pacheco Boulevard mapping corridor. During our field surveys, LCC was only able to recover five (5) of these benchmarks, and was only able to survey four (4) of these with GPS methods. The benchmarks search for but not found (appeared to be destroyed) were BM1371, BM1629, BM3011, and BM3736. The benchmark that was found but that wasn't surveyed was BM1630. The four (4) benchmarks found and surveyed were BM0999, BM 3094, BM3469, and BM3737. For these found benchmarks, we believe that the resulting averaged coordinates and elevations have the following approximated statistical 95% confidence in relative accuracy: ±0.02 feet horizontally, and ±0.04 feet vertically. Calculated datum conversion equations based on the average of shots and the record information is as follows: BM0999 - NAVD88 = NGVD29 + 2.68 ft; BM3094 - NAVD88 = NGVD29 + 2.65 ft; BM3469 - NAVD88 = NGVD29 + 2.66 ft; and BM3737 – NAVD88 = NGVD29 + 2.65 ft. These adjustment calculations are with the expected range of 2.6 ft to 2.7 feet. However, it should be noted that our project NAVD88 elevations are based on a County GPS control point, which were established originally using GPS and listed only to the nearest 0.1 feet on the published data sheet.

Resurvey of the County Precise Line: The County provided LCC with two sets of Precise Alignment maps of Pacheco Boulevard (County Road No 3951). The first set of maps was approved by the Board of Supervisors on February 15, 1962, and showed the alignment of Pacheco Blvd from Bush Street to Arthur Road. The second set of maps was approved by the Board of Supervisors on July 23, 1968, and showed the alignment of Pacheco Blvd from Arthur Road to Blum Road. Comparing these two maps to each other, we were able to confirm that the coordinate system and basis of bearings are the same.

To recreate the County Precise Alignment lines, we located several monuments shown along the alignment. For calculation purposes, we held the monument the coordinates of the monument in the middle of the project at Arthur Road, and rotated the precise alignment (calculated using the 1962 and 1968 maps) through the found monument at Morello intersection (north end of project alignment). This adjustment resulted in a difference of only -0.11 ft (measured vs. calc) horizontally at the Morello intersection monument. Also, comparing to the found monument near Blum Road (south end of project alignment), the adjustment resulted in a similar difference of only -0.11 ft (measured vs. calc) horizontally along the alignment line, and a rotational error of only 0.02 ft perpendicular to the calculated alignment. Based on these numbers, we accepted the County's precise alignment calculations, and translated to the coordinates held at the Arthur Road monument and rotated the bearings through the monument at Morello Ave. Of the remaining surveyed precise alignment monuments which were still in existence, two of the monuments checked within 0.01 ft of the precise line, and two of the monuments checked within 0.05 ft of the precise line (measured perpendicularly with precise line).

Final Survey Files and Data: LCC will deliver to the City and County a CAD file containing all adjusted survey data of the horizontal and vertical control points, along with points and labels and a digital ASCII file of the data. We will also deliver a printed list of control point values, and raw data point analysis spreadsheets for both aerial control points and the monuments/benchmarks together with a digital copy of the orthophotos.

2. Document Research

Assessor's Parcel Maps: The Assessor's Maps located in the County Public Works Department were consulted for documentation of Records of Surveys, Parcel Maps, Subdivisions and Deeds with containing Right of Way Dedications. These maps were compiled for the east and west side of Pacheco Boulevard.

Record Maps: Copies Subdivision Final Maps, Parcel maps, Records of Survey, and Corner Records of maps shown Right of way dedications shown on those maps were compiled.

Right of Way Surveys: Copies of the County precise line dated February 15, 1962 and July 23, 1968 were obtained along with Caltrans right of way surveys at the intersections of Arthur Road and State Route 4.

3. Aerial Photography and Topographic Mapping

PROJECT DIAGRAM

Survey Control: LCC provided the 27 ground control points generally shown on Figure 1. The flight crosses were generally 3 feet comer to comer by 3 inches wide.

Aerial Photography and Stereo Compilation and Mapping: Tetra Tech, under contract to LCC provided the following products and services:

- aerial photography, 19 B& W mapping exposures at 1 :2400
- analytical aerotriangulation for densification of control
- stereo-compilation of planimetry and terrain data and generation of contours on a 1 foot interval, supplemented by spot elevations as appropriate.
- assembly and edit of data files at 1 "=20'
- translation to AutoCAD format using Tetra Tech standard blocks and named layers

Orthophotography: Tetra Tech generated orthophotos using a solution from the aero triangulation and the collected Digital Terrain Module (DTM). Imagery was limited to the extents of the mapping. Orthophotography was delivered in tif/tfw format with a pixel resolution of 0.2 feet.

Topographic Base Maps: The images received from Tetra Tech were inserted into title block sheets and stationing assigned from north to south beginning approximately 800 feet north (west) of the intersection of Morello Avenue. Photo strips were positioned on the sheets with the ortho photos on top and the photogrammetry beneath. The maps were plotted to a scale of 1 inch = 40 feet. 10 sheets were required to cover the distance from west of Morello Avenue to the Blum Road/SR 4 Ramps. A title sheet with a location map and index of sheets was then added.

Enclosures: Final Survey Files (Digital)

1. CAD File containing adjusted survey data of the horizontal and vertical control points along with points and labels and a digital ASCII file of the data.
2. List of control point values and raw data ppoint analysis spreadsheets for aerial control points and monuments/benchmarks.
3. Digital copy of the orthophotos.

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